Physical Mechanisms of Quarry Blast Sources

T.G. Barker, K.L. McLaughlin and J.L. Stevens

S-CUBED, a Division of Maxwell Laboratories
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ABSTRACT

Quarry mining practices vary considerably within the United States and worldwide, the variations reflecting the materials that are to mined, the means for removing and processing the materials, operator preferences, safety considerations and constraints imposed by nearby population and structures. Models of quarry blasts that can be used to develop efficient and robust methods for discriminating quarry blasts from other source must reflect the varied practices. Development of models for quarry blasts was the subject of work done at S-CUBED under a previous contract to ARPA. Under a new contract to DoE (which has not been initiated), we will validate and extend the models using using near-source and regional data. Our objective will be to use the models to determine the sensitivity of proposed regional discriminants to varied mining practices.

OBJECTIVE

The objective of the work to be undertaken is to develop an understanding of the physical processes of quarry blast sources as they affect discriminants using regional signals. We will build on previous modeling studies at S-CUBED, incorporating realistic and varied practices from mines in regions of CTBT interest. These models will be used to determine the sensitivity of discriminants to features of quarry blasts. This modeling will include 1D, 2D and 3D calculations.

RESULTS of MODELING RESEARCH

The objective of the previous project was to provide a theoretical basis for the discrimination of quarry blasts from earthquakes and nuclear tests, and to evaluate an evasion scenario of simultaneously exploding a nuclear test beneath a quarry. The quarry blast source models incorporated the effects of ripple fired sources, the finite size and duration of the source, the horizontal and vertical movement of spalled material, the relative excitation of the explosive charges and the spall process, and the bench topography.

From the calculations, we made the following conclusions. Conclusions 1 through 7 are the result of the relative excitation of the explosive and spall components of the source and the relatively long duration of the quarry blast. Conclusions 8 through 11 are the result of the quarry geometry.

(1) The quarry blast source is a band-limited signal compared to the overburied bomb.

(2) Pg spectral values rise in the band from 0.5 to 3.5 hz for a bomb, but decay in that band for the quarry blast.

(3) Spall strongly affects the quarry blast source. Peak Pg and Lg amplitudes from spall and from the explosive charges are comparable.

(4) Quarry blast spectral scallops are primarily due to the finite size of the source and are insensitive to the details of ripple firing.

(5) In simultaneous explosion and quarry blast, the explosion will dominate if the explosion yield (tamped or equivalent decoupled) exceeds approximately 10 percent of the quarry blast yield.

(6) Seismic amplitudes are insensitive to the direction of spall as long as there is minimal elevation change.

(7) An elevation change (the spalled face falling to a lower level) can significantly increase seismic amplitudes from quarry blasts. An elevation change of 10 meters can increase the signal by as much as a factor of 5 in the 2-5 Hz band.

(8) Two-dimensional simulations show that seismic signals from point explosion (dilatational) sources located behind the quarry face can be reduced substantially in amplitude, while seismic waves from sources on the quarry floor may be amplified. Seismic signals from point forces are affected very little by proximity to the quarry face. The source amplitude variations occur for sources within about one bench height of the quarry face.

(9) An extended source in the standard configuration averages these variations leading to a source that is reduced slightly in amplitude relative to a source in a half space.

(10) Results (8) and (9) are nearly independent of the takeoff angle of the seismic signal.

(11) Three-dimensional simulations show that the quarry creates a shadow for signals exiting the the quarry on the side opposite the bench.

RECOMMENDATIONS AND FUTURE PLANS

The primary focus of future work will be to test the models described above against observations, incorporate world wide blasting practices and evaluate identification procedures for quarry blast sources.